UNIVERSIDAD DISTRITAL FRANCISCO JOSÉ DE CALDAS

Tecnura

http://revistas.udistrital.edu.co/ojs/index.php/Tecnura/issue/view/650

DOI: http://dx.doi.org/10.14483/udistrital.jour.tecnura.2015.ICE.a16

ESTUDIO DE CASO

Islanding operation's effects of distributed generation on distribution networks

Efectos de la operación en isla de generación distribuida en redes de distribución

Alejandro Pedraza[1], David Reyes[2], Carlos Gómez[3]

Fecha de recepción: Agosto 28 de 2015 **Fecha de aceptación:** Septiembre 25 de 2015

Como citar: Pedraza, A., Reyes, D., & Gómez, C. (2015). Islanding operation's effects of distributed generation on distribution networks. Revista Tecnura, 19 (CITIE), 145-150. doi: http://dx.doi.org/10.14483/udistrital.jour.tecnura.2015.ICE.a16

Resumen

En este artículo se presentan los efectos e inconvenientes que se presentan en una red de distribución al operar con fuentes de generación distribuida de modo aislado. Se trabajaron dos situaciones específicas: isla intencional e isla no intencional, analizando principalmente la influencia sobre las corrientes de carga, los perfiles de tensión y la frecuencia del sistema. Para tal estudio se utilizó y modeló la red de distribución de 37 nodos de IEEE, localizando los recursos distribuidos en diferentes nodos y variando el nivel de penetración de 100 kW a 1200 kW.

Palabras clave: generación distribuida, operación en isla, red de distribución, flujo de carga, perfiles de tensión.

Abstract

In this paper the effects and issues due to islanding operation with distributed generation in a distribution network are shown.Two specific conditionsare assessed (intentional island and unintentional island) by analyzing the main influence on load currents, voltage profiles and frequency of the system.Whence, the IEEE 37 nodes test grid was modeled and distributed resources locations were varied along the network whilst its capacity is changed from 100 kW to 1200 kW.

Keywords: distributed generation, distribution network, islanding operation, load flow, voltage profile.

[1] ElectricalEngineer, Universidad Distrital Francisco José de Caldas, Bogotá D.C., Colombia. Contact: alejandropedrazagiraldo@hotmail.com.
[2] ElectricalEngineer, Universidad Distrital Francisco José de Caldas, Bogotá D.C., Colombia. Contact: david_fydx@hotmail.com.
[3] ElectricalEngineer, Universidad Central, Bogotá D.C., Colombia. Contact: cgomezv1@ucentral.edu.co.

INTRODUCTION

One of the chief advantages of distributed generation's (DG) high penetration is the possibility of operating distribution systems in islanded mode. Islanding operation is a situation in which a distribution network becomes electrically isolated from the rest of power system due to some sort of disturbances such as a fault upstream. In this case, the grid keeps being energized by DG causing an increase of distribution system reliability [1], [2].

Isolated DG operation is a controversial topic of discussion between utilities and customers. That unfair disagreement results from the lack of regulations between both parts. Indeed, power providers believe their responsibility of supplying electrical energy service has more priority over the DG owners. For utility, there is a high risk of equipment failure as well as islanding operation generator stuff's safety and security affectations whose control is managed by the customers[3].Utilities usually are opposed to any existence of island operations if causing main feeder disconnection. However, for customers who are owners of DG the island condition may represent continuous electrical service under some conditions of reduction of power, voltage drops, frequency variations and limited production capacity. Which means less economic losses compared to those experience voltage sags or blackouts [4], [5].

In this paper islanding operation effects of distributed resources on distribution networks are shown, assessing load current changes related to DG's capacity and load demand whilst working on islanding condition.

METHODOLOGY

Survey case

The IEEE 37 nodes test grid represents a grid topology located in California, United States. The network has got its main bar on 799 nodes, which represent substation output with nominal values of power and a voltage 2500 kVA and 230 kV/4.8 kV respectively. Additionally, it contains a three-wire underground structure. The current grid model including underground cables as well as loads, main substation and transformer were performed according to [6].As a criterion of selection, the grid topology was divided into seven sections, which later on became branch circuits powered by the main feeder. Whence, thirty-five of distributed resources locations were assessed by switching levels of capacity from one to seven, that process is explained in detail below, ending up in two hundred forty five examples evaluated. According to the outcomes in [7], some of the test subjects were chosenin order to be assessed through an optimization methodology on the IEEE 37 nodes test feeder. At the end, both, the most beneficial and the least useful DG locations were found.

Intentional Island

An intentional island is a planned condition where part of the system is powered byone or more local generators that are electrically separated from the network [8]. The network evaluation was made in a number of steps. In the first stage, an attempt of islanding operation was intentionally made, focusing on the changes caused on load currents and voltage profiles.Based on [7], the test subjects most affected by DG presence across the sevenareas were: in the first place, node 710 for having the least load demands valueof the grid (127 kW). Secondly, node 713 that has a load demandmean (538 kW) in comparison to the rest of loads. Finally, the node 701 is the zone where the biggest load demand of the red was connected (968 kW).

Load currents

Working on island operation, the energy supplied to the loads must be bigger enough than their own demands. Otherwise, the low DG capacity is more likely to cause an overload affecting the area's method of operation which is isolated from the main feeder [9], [10].Therefore, load currents were assessed by varying DG capacity from 100 kW to 1200 kW.

Case 1: DG capacity equal to load demand

Having compared flow load values, while islanding operation as well as DG connectionwas going on, with power levels nearly to load demands (see table 1) some inconveniences appeared for those capacities lower than 127 kW. For example, assuming the generator capacity is over 100 kW implies an overloaded operation. Another problem is when DG capacity is higher than load demands (Levels from 400 to 1200 kW).

Case 2: DG capacity higher than load demand

In this case the power demand level is 538 kW localizing an island at node 713 powered by DG. Equally capacity levels were switched from 100 to 1200 kW. In table 2, load current values flowing through different branches of the zone when operating in isolated form.

It is observed that if the load demand is less than DG capacity (from 600 to 1200kW), load currents are very similar to nominal ones when the main feeder's capacity is close to load maximum demand. Otherwise, a DG overload would take place.

Case 3: DGcapacity lower than theload demand

In this test subject a DG was located in the node 701, which belong to main zone protected by the only switch available in the network. Besides, it has got the highest load demand level of the grid (968 kW). Furthermore, once again the level of DG capacity source was varied from 100 to 1200kW.

Table 1. Load currents (A) in the island with DG located in 710 node.

	100kW	200kW	400kW	600kW	800kW	1000kW	1200kW	FEEDER
710-736	18.49	11.58	32.51	18.52	18.48	18.52	18.5	10.12
710-735	16.32	10.78	16.36	16.33	16.32	16.30	16.31	20.50

Source: Own work.

Table 2. Load currents (A) in the island with DG located in 713.

	100kW	200kW	400kW	600kW	800kW	1000kW	1200kW	FEEDER
713-704	68.80	68.12	68.13	72.57	72.45	72.66	72.67	74.24
704-714	30.85	30.86	30.87	21.55	21.54	21.56	21.56	26.93
714-718	23.59	23.59	23.61	14.50	14.46	14.46	14.46	20.08
704-720	51.59	51.64	51.66	55.69	55.73	55.84	55.88	69.37

Source: Own work.

Table 3. Load currents (A) in island with DG located in 701 and demand of 968 kW.

	100kW	200kW	400kW	600kW	800kW	1000kW	1200kW	FEEDER
701-702	72.85	72.84	72.82	72.85	72.69	72.84	92.89	276.32
703-730	72.85	72.84	72.82	72.85	72.69	72.84	92.97	196.65
733-734	53.13	53.13	53.12	53.13	53.11	53.14	70.85	109.33
737-738	25.15	25.15	25.14	25.15	25.11	25.15	33.61	53.14

Source: Own work.

For capacities of generation lower than load demands, load currents were not affected sharply. On the other hand, their values in comparison with the nominal ones, powering just by the main feeder, decreased.

Those differences might have been due to the high number of nodes connected in this area as well as the long distances between the loads from the man feeder.

Voltage profiles

Voltage profiles were analyzed in every single node belonged to the zone where island operates and compared with nominal values.

The most critical cases showed up when load demands exceeds and/or is nearly DG capacity. Thus, voltage magnitudes reached a maximum of 6% and 5% of deviation (in absolute value taking as reference the voltage of 1 p.u.), in case 1 and case 3 respectively. Additionally, the highest differences are caused in the node 733.

By including DG with a power over the zone's load demand value, voltage magnitudes are approaching to 1 p.u., reaching maximum differences up to 2% as well as improving maximum deviation in 4% that occurs when main feeder is who operates (see fig. 2).

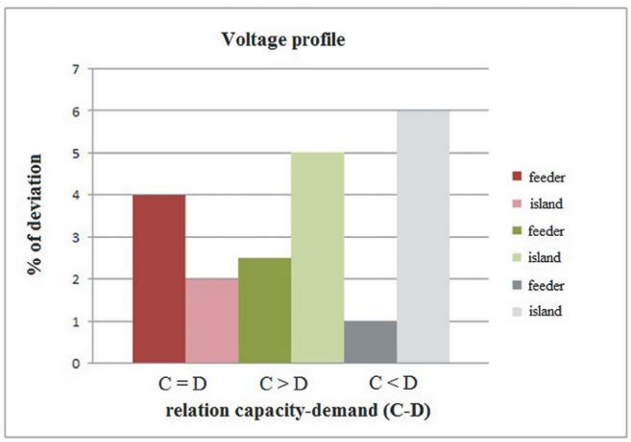

Figure 1. Voltage profile before and after of islanding operation.

***Source*:** Own work.

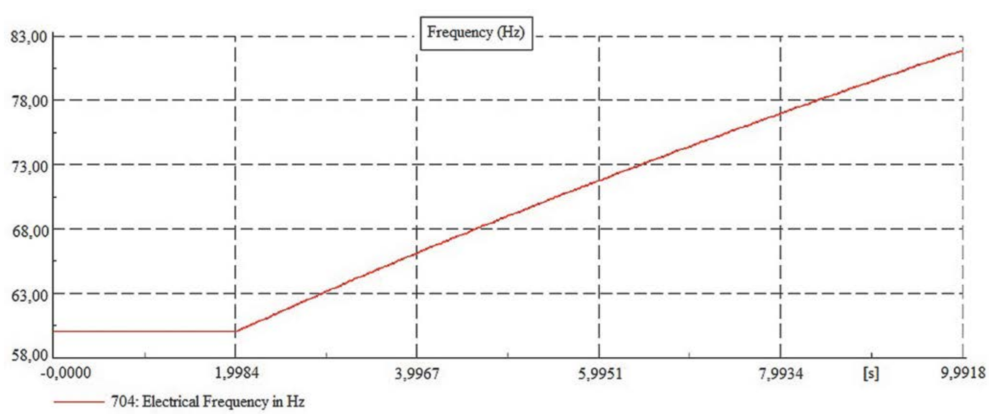

Figure 2. Levels of frequency operating in island mode after a failure.

Source: Own work.

In conclusion, voltage profiles would work efficiently as long as the load demand level remains lower than DG capacity value when islanding operating.

Unintentional Island

An unintentional island occurs by opening a circuit located upstream of DG connection.It leaves the part of the system downstream powered only by distributed resources connected in that point. The opening of the circuit usually is the result of the action of a switch, recloser o fuse from the main feeder in response to a failure [11]. As a consequence, one of the most significant drawbacks is related to variations of the frequency. For example, if using a random test subject wherea 1200 kW DG is located in the node 744 and a failure occurs in the node 702 while the main feeder keeps powering the red, it would enhance the fault current level until protection system coordination is lost (confirming results in [7]). Indeed, the fuse operatesbefore that recloser's fast curve operates. As a result, an unintentional islanding operation in that zone of the grid is created.

Figure 1 shows the variations on frequency against time after having cleared the failure, causing an island operation powered only by a DG. During the analysis of this particular test subject the load demand is 252 kW which is lower than DG capacity level. After a failure in the grid, the protection system acts straight away (2 s), resulting in an increment in the levels of frequency due to island operation.

CONCLUSIONS

Distributed generation sources and islanding operation working together is a desirable and functional mode when levels of generator capacity and load demands are relatively close. The purpose of this gathering is to accomplish the electrical energy supplies across the network, decreasing financial losses and improving the service givento the final users.

It is necessary to take into account that under no circumstances should load demand levels be higher than DG capacity if islanding operation is desired. Thus, deterioration of components and inefficient distributed sources working are avoided. Also, the condition *"load demand << DG capacity"* is not recommended in order to avoidany genre of inconveniences or damage to the grid.

When operating in unintentional island, one of the most significant drawbacks is related to frequency variations, precisely when the load demand is muchlower than DG source capacity. Under this condition, levels of frequency tent to rise sharply.

Intentional islanding operation could be a support for the network whilst clearing failures or maintaining one or more zones of the grid, since it contributes to avoid power losses as well as keeps supplying electrical energy to non-failure loads.

FINANCIAMIENTO:

Universidad Distrital Francisco José de Caldas

REFERENCES

[1] Mahat, P., Chen, Z., Bak-Jensen, B. &LethBak, C., A simple adaptive overcurrent protection of distribution systems with distributed generation. *IEEE Transactions on Smart Grid*, vol. 2, No. 3, pp. 428-437, 2011.

[2] Fuangfoo, P., Meenual, T., Lee, W., Fellow &Chompoo-inwai, C., PEA guidelines for impact study and operation of DG for islanding operation. *IEEE Transactions on industry applications,* vol. 44, No. 5, 2008.

[3] Dewadasa, M., Ghosh, A. &Ledwich, G., Protection of distributed generation connected networks with coordination of overcurrent relays, *ECON 2011–37th Annual Conference on IEEE Industrial Electronics Society*, Queensland University of Technology: Australia, 2011.

[4] Gomez, J. & Marcos, M., Distributed generation: exploitation of islanding operation advantages, *T& D*

Conference and Exposition: Latin America, America, 2008.

[5] Fuangfoo, P., Lee, W. &Nigim, K., Intentional islanding operation to improve the service reliability of Thailand electric power system, *IEEE Power Engineering Society General Meeting,* 2007.

[6] Funmilayo, H., Silva, J. & Butler-Purry, K., Overcurrent protection for the IEEE 34-Node radial test feeder, *IEEE Transactions on Power Delivery*, vol. 27, No. 2, 2012.

[7] Pedraza, A., Reyes D., Gomez, C. & Santamaria, F., Optimization methodology for distributed generation location in distribution networks assessing protections coordination, *IEEE Latin America Transactions,* vol. 13, No. 5, 2015.

[8] Mohamad, H., Mazaher, H. & Abu Bakar, A., Feasibility study of an intentional islanding operation with a new adaptive load shedding, *3rd International Conference on Electric Power and Energy Conversion Systems,*Istanbul: Turkey.

[9] Jahdi, S. & Lei, L., DG islanding operation detection methods in combination of harmonics protection schemes, *2nd IEEE PES International Conference and Exhibition on Innovative Smart Grid Technologies,* London: UK.

[10] Pilo, F., Celli, G. & Mocci, S., Improvement of reliability in active networks with intentional islanding, *IEEE International Conference on Electric Utility Deregulation, Restructuring and Power Technologies,* Hong Kong, 2004.

[11] Walling, R. & Miller, N., Distributed generation islanding – implications on power system dynamic performance, *Power Engineering Society Summer Meeting, IEEE*, vol.3, 2002.